correct as far as the weights of individual nucleides were concerned. Non-integral atomic weights are mainly due to the presence of isotopic mixtures in the usual samples of elements. The ordinal number of Newlands' "rank order" of elements became identified in 1913 by Henry Gwyn-Jeffries Moseley (1887-1915) with the number of increments that the square root of the frequency of X-rays must be shifted to predict the correct X-ray frequency for a given element (15). The ordinal number became the atomic number, the integral positive charge and number of protons of an atom's nucleus and the number of electrons surrounding it. But these Pythagorean identifications once again did not account for the diversity of chemical properties. That was achieved by arranging the electrons in superbly simple Pythagorean patterns, by recognizing that similar chemical properties imply similar arrangements of electrons. We are the true inheritors of an idea 2500 years old - that the properties of the elements are the properties of numbers (16).

References and Notes

Acknowledgments: An early version of this paper was presented at the Mendeleev Symposium, December 1969, Annual Meeting of the American Association for the Advancement of Science. It was originally prepared for publication to honor the chemist and chemical educator Ronald J. Gillespie on his 65th birthday, but was considered too historical for the special issue (November 1989) of the *Canadian Journal of Chemistry* published in his honor.

1. K. Popper, "The Nature of Philosophical Problems and their Roots in Science," *Brit. J. Phil. Sci.*, **1952**, *3*, 124-156, quoted in S. Toulmin and J. Goodfield, *The Architecture of Matter*, Harper and Row, New York, 1962, p. 80.

2. G. Sarton, *Introduction to the History of Science*, Vol 1, Carnegie Institution, Washington, DC, 1927 p. 113.

3. J. Kepler, *The Six-cornered Snowflake* (1611), edited and translated by C. Hardie, Oxford University Press, 1966, p. v.

4. A. J. Rocke, "The Reception of Chemical Atomism in Germany," *Isis*, **1979**, *70*, 519-536.

5. M. Pettenkofer, "Ueber die regelmässigen Abstände der Aequivalentzahlen der sogenannten einfachen Radicale," *Gelehrte Anzeigen Akad. Wissenschaft. München*, **1850**, *30*, 261-272; reprinted with new Introduction by author in *Ann.*, **1858**, *105*, 187-202.

6. J. B. A. Dumas and J. Liebig , "Note sur l'état actuel de la chimie organique," *Comptes rendus*, **1837**, *5*, 567-572.

7. J. B. A. Dumas, "Mémoire sur les equivalents des corps simples," *Comptes rendus*, **1857**, *45*, 709-731.

8. For J. A. R. Newlands' collected papers, see his *The Discovery of the Periodic Law and on Relations Among the Atomic Weights*, Spon, London, 1884.

9. Two other early and very Pythagorean pioneers of element classification were the French geologist, Alexandre Emile Béguyer de Chancourtois, and the Danish-American chemist, Gustavus Detlef Hinrichs. For further details see J. W. van Spronsen, *The Periodic System of Chemical Elements: A History of the First Hundred Years*, Elsevier, Amsterdam, 1969.

10. L. Meyer, *Die Modernen Theorien der Chemie*, Maruschke and Berendt, Breslau, 1864.

11. D. M. Knight, *The Transcendental Part of Chemistry*, Dawson, Folkestone, Kent, 1978, p. 256.

12. L. Meyer, "Die Natur der chemischen Elemente als Function ihrer Atomgewichte," *Ann., Suppl.*, **1870**, *7*, 354-364.

13. D. I. Mendeleev, "The Relation Between the Properties and the Atomic Weights of the Elements," *Zhurnal Russkago fiziko-khimichescago obshestva*, **1869**, *1*, 60-77 (in Russian); a brief German abstract of this paper appeared as "Ueber die Beziehungen der Eigenschaften zu den Atomgewichten der Elemente," *Z. Chem.*, **1869**, *12*, 405-406.

14. K. Seubert, "Zur Geschichte des periodischen System," *Z. anorg. Chem.*, **1895**, *9*, 334-338.

15. H. G-J. Moseley, "The High Frequency Spectra of the Elements," *Phil. Mag.*, **1913**, *[6]26*, 1024-1034.

16. Since writing the original draft of this lecture several additional references have come to my attention. W. B. Jensen, "Classification, Symmetry and the Periodic Table," *Comp. & Maths. with Appls.*, **1986**, *12B(1/2)* 487-510, has examined the structure and development of the periodic table in the light of a wide range of contemporary mathematical concepts. These observations have been further expanded within an historical context in his *From Triads to Aufbau: Twelve Lectures on the Nature and History of the Periodic Law*, based on lectures given at the 1991 Beckman Center Workshop on the History of Chemistry and at the 1992 Woodrow Wilson Institute at Princeton and due to be published next year. Also of great interest is the paper by E. Ströker, "Die Ordnung der Elemente: Entstehung und Bedeutung des Periodensystems," in W. Sawodny, R. Opferkuch, and A. Schunk, eds., *Chemie im Spiegel der Jahrhunderte*, Universitätsverlag, Ulm, 1992, pp. 67-79.

Theodor Benfey is editor for the Chemical Heritage Foundation, 3401 Walnut Street, Philadelphia, PA 19104, and Adjunct Professor at the University of Pennsylvania. Author, editor and translator of several books on the history of chemistry, former editor of the ACS magazine "Chemistry," a past-chair of the Division and a current member of the editorial board of the Bulletin, *he is particularly interested in the history of organic chemistry, the history of Japanese and Chinese science, and the development of the dye industry.*

BOOK NOTES

Curiosity Perfectly Satisfyed: Faraday's Travels in Europe 1813-1815, Edited by Brian Bowers and Lenore Symons, Peregrinus, London, 1991. xvi + 168 pp. Cloth (Typeset), $33.00. *Michael Faraday's 'Chemical Notes, Hints, Sugges-*

tions and Objects of Pursuit' of 1822, Edited by Ryan D. Tweney and David Gooding, Peregrinus, London, 1991. xvii + 152 pp. Cloth (Typeset), $55.00. *The Correspondence of Michael Faraday, Volume 1, 1811-1831*, Edited by Frank A. J. L. James, Institution of Electrical Engineers, London, 1991. xlix + 673 pp. Cloth (Typeset), $104.00.

Yet more fallout from the Faraday bicentennial. These three very different books all treat of Faraday's formative years when, somewhat self-consciously, he was furthering his delayed education and pursuing his scientific ambitions. In *The Life and Letters of Faraday*, Bence Jones devotes 128 pages to "extracts from his journal and letters whilst abroad with Sir Humphry Davy" but he is forced to admit that "the journal ... is remarkable for the minuteness of the description of all he saw, and its cautious silence regarding those he was with." Bence Jones seemingly had access (the perfunctory preface is vague on this) to Faraday's original manuscript, now lost, as well as to the "fair copy" which survives and from which the transcript given in *Curiosity Perfectly Satisfyed* is derived. As in Bence Jones, the Journal proper is fleshed out with letters Faraday wrote to friends and relatives at home. While it is good to have the complete text in print, it cannot be said that the new material does much to satisfy our curiosity about how the constant company of Davy contributed to Faraday's maturation as a scientist. His accounts of Davy's experiments and observations on iodine, hot springs, rocks, the combustibility of diamond, and so on, are strangely dispassionate. How one wishes entries such as "*T.22*. The day principally employed in the laboratory. *W.23*. The same as yesterday." were expanded and the often tedious baedekering reduced:

> Proceeding straight from this gate into the city the eye is caught by the ruins of a dome or vault in a vineyard on the right hand. They are the remains of a temple erected to Minerva Medici or the goddess of health. It is of brick and of a diagonal form. Farther on were the ruins of the Chateau de l'eau Juilie commonly called the trophies of Marcus because ...

It is hard to decide whether such passages reflect mere boredom, unconscious plagiarism or self-mockery. Certainly Faraday was no Byron, but then Byron was no Faraday. Most of the nuggets have been previously mined by Bence Jones and L. Pearce Williams, but there are many incidental small pleasures: Faraday's enjoyment of carnivals ("went in a domino to the mask ball this morning and was much amused"); his paean to French bread ("it has a positive excellence that one would not wish it surpassed, beyond what is would be undue luxury"); and this backhanded tribute to the climate of Montpellier ("that climate which when united to the medical abilities of the faculty no disease can withstand"). Above all there is his obvious joy in minute observation of the works of nature in sharp contrast to his dutiful observation of the works of man. For Faraday, the GLOWWORM!!! (his capitals and his exclamation points) was far more fascinating than all the architectural grandeur that was Rome.

The second of these books, the handsomely produced *Michael Faraday's 'Chemical Notes, Hints, Suggestions and Objects of Pursuit' of 1822*, is a curious piece of work. It is in three parts: a somewhat tendentious introduction (much of the substance of which has already appeared in this *Bulletin* (**1991**, *11*, 51-55), a complete photographic facsimile of the manuscript with facing-page transcription, and an idiosyncratically interesting glossary. The editors open boldly:

> The notebook that we are publishing here is a remarkable document. Kept by one of the major scientists of the nineteenth century, at a time when he had made his first important discoveries and was preparing for those major findings that would propel him into the very first ranks, it is a window into the thoughts of a scientific genius and, at the same time, a revealing portrait of the culture and community of a new century in the history of science.

and quote Faraday's own estimation approvingly:

> I already owe much to these notes and think such a collection worth the making by every scientific man. I am sure none would think the trouble lost after a year's experience.

What is there to justify such a high assessment? As can be seen from the splendid photographic plates, there is little problem with Faraday's exemplary handwriting. After all, this was one reason why Davy had hired him as a temporary amanuensis. The motivation, purpose, and utility of what he wrote, however, remain obscure in spite of the editors' efforts. They have transcribed but not, or at least not completely, deciphered. Superficially we have a book of lists. At times the lists seem almost random: "Sinking of ice" comes between "Colour of eyes" and "Triple tartrate of ammonia and antimony"; "Shadows of thumb from several windows?" between "Crystallisation in Cods headbones - boil long time", and "Sol of soluble Prussian blue on yellow ferro-prussiate?" At other times the lists are tightly categorized under familiar heads - "Sulphur", "Electricity", "Organic Chemistry" - though even here Faraday's restless imagination keeps breaking the bounds. Some of the entries refer to work already in the literature (though they are rarely referenced) while others are objects to pursue. Many of the latter Faraday (and others) subsequently did pursue, but Tweney and Gooding do not attempt any kind of concordance apart from a brief "Table of Correspondences" drawn solely from Faraday's relatively rare annotations. Cursory reference to *Experimental Researches on Chemistry and Physics* would reveal, for example, that "Passage of gases through tubes" had already been addressed in 1818 and "For Julin's (not Julens) chloride carbon" in 1821, while a detailed examination of "Light through liquid with precipitated gold" had to wait until near the end of Faraday's life. Even a partial concordance with Thomas Martin's magisterial edition of the *Diary* and, through him, with Faraday's published work might reveal more of what he was about than the vague speculations on "cognitive processes" found in the introduction. What we have here is an intriguing historical/scientific mystery story and Tweney and Gooding are to be thanked for making the "documents in the case" available and for providing an interesting and novel contemporary glossary that will help the interested reader in search of clues.

With the last of these three books, there can be no quarrel. Many of Faraday's letters are readily available in print, particularly in Bence Jones and in L. Pearce Williams' *The Selected Correspondence of Michael Faraday.* For the years 1811-1831, Frank James' new compilation of all the surviving letters more than doubles the number of entries in Williams' work. While some of the additions would scarcely have been missed (e.g., letters 6, 22, 29, etc.), there is no arguing with completeness and others (e.g., letters 30, 56, 58, 105, etc.) are valuable additions to the published canon. Thirty of the letters are from the peripatetic Davy. Though couched in polite terms, these peremptory notes show that Sir Humphry often considered Faraday something of a personal lackey long after they had returned from Europe. With one exception, this one-sided exchange ended at the time of the Wollaston affair. Were there no more such notes or have they merely not survived? That Faraday treasured the first of the series is evident from letter 419. The scholarly apparatus is extensive and impeccable, though one questions the necessity of including "Newton, Isaac" sandwiched between "Newman, John" and "Nicholl, Whitlock" in the Biographical Register. Perhaps as a sign of the scholarly times, all letters in French and Italian have been admirably translated into English by the editor's wife. The book reproduces many of Faraday's spidery drawings and is illustrated by 13 black and white plates of variable quality.

This last quibble brings up my only real complaint. For a book listing at $104, this is a mean and crabbed production, particularly when compared with Williams' splendid two-volume set and the other two books reviewed here. The dedicatee, whose own binding graces the dust-jacket of *Chemical Notes*, wrote in his travel *Journal*:

> Went into the workshop of bookbinder and saw there the upper part of a fine Corinthian pillar of white marble which he had transformed into a beating stone of great beauty. Found my former profession carried on here with very little skill neither strength nor elegance being attained.

He would not be any better pleased by the present production. However, we must give thanks for present if expensive mercies and look forward expectantly to the appearance of James the Second. *Derek A. Davenport, Department of Chemistry, Purdue University, West Lafayette, IN 47907.*

The Green Flame: Surviving Government Secrecy, Andrew Dequasie, American Chemical Society, Washington, DC., 1991. xii + 220 pp. Cloth (Typeset), $22.95.

This is a truly outstanding book, written by one of the participants in the U.S. government-sponsored program to develop boron-based jet fuels at the height of the Cold War in the 1950s. It has a light-hearted chatty style, which demonstrates that chemistry (and chemists) need not be boring, but it is also a serious book, packed with new information and a penetrating analysis of a major defense-related research program. *The Green Flame* is a richly textured book, with several different levels. Fundamentally, it is an account of one young chemist's personal development in the 1950s. It is also a hard-headed analysis of a government-sponsored defense-related program that was excessively dangerous and expensive, and which threatened to spiral out of control. Dequasie stresses the role of government secrecy which permeated and hindered the research program. But it is also a fine account of chemical innovation, of how a dedicated team of chemists developed a potentially viable boron-based fuel in the face of numerous technical problems and personal danger. On a more technical level, Dequasie provides many interesting facts about boron hydride chemistry. However, the main charm of this splendid gem of a book lies in its evocation of 1950s America, an era of innocence during which the goodness of the American way was unquestioned, patriotism was the supreme virtue, and researchers assumed their government knew what was best. *Peter Morris, The National Museum of Science and Industry, London, SW7-2DD, England.*

The Chemical Revolution: A Contribution to Social Technology. Archibald Clow and Nan L. Clow, Gordon and Breach, Philadelphia, PA., 1992. xx + 680 pp. Paper (Typeset), $33.00.

This quality reprint of the classic 1952 monograph by the husband-wife team of Archibald and Nan Clow forms volume 8 of Gordon and Breach's reprint series "Classics in the History and Philosophy of Science." Readers familiar with the literature dealing with the history of chemical technology will need no introduction to this book, which was and remains the definitive study of the rise of the heavy chemical industry in Great Britain (with special emphasis on Scotland) in the period 1750-1830. As indicated by their provocative title, the Clows consider this event to be a true "industrial" chemical revolution, which paralleled the well-known academic chemical revolution born of Lavoisier and his collaborators. The quality of this reprint, including that of the numerous illustrations, is excellent, the price is reasonable, and a new introduction has been added by Frank Greenaway, formerly of the London Science Museum. On all these counts Gordon and Breach are to be congratulated, but most of all for the simple act of making this wonderful volume available again to a new generation of chemical historians. *William B. Jensen, University of Cincinnati, Cincinnati, OH 45221.*

The French Paracelsians: The Chemical Challenge to Medical and Scientific Tradition in Early Modern France. Allen G. Debus, Cambridge University Press, Cambridge, 1991. xvi + 247 pp. Cloth (Typeset), $64.95.

This volume represents another installment in Allen Debus's life-long commitment to the study of iatrochemistry. Beginning with his 1964 monograph, *The English Paracelsians*, and continuing through his two-volume classic, *The Chemical Philosophy: Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries* (1977), and his later monographs, *Man and Nature in the Renaissance* (1978) and *Chemistry, Alchemy and the New Philosophy, 1550-1700* (1987), as well as in numerous articles and lectures, Debus has pursued his study of this key transitional period in the history of both medicine and chemistry with single-minded purpose and dedication. This latest volume is up to his usual high standards of scholarship and provides us with yet another key to understanding this enormously complex movement which, while challenging the rationalism of new mechanical philosophy, managed at the same time to precipitate indirectly the transition of chemistry from the very mysticism which it advocated into the modern science we know today. As with his previous studies, Debus's portrayal of the debates, which racked the French medical community from the middle of the 16th century through the early 18th century, clearly shows the complexity of this event and how unintentionally misleading are the versions which appear in the average history of chemistry text. By divorcing the purely chemical aspects of this movement from the broader medical and philosophical issues, which gave this chemical content its meaning, the resulting textbook accounts of iatrochemical discoveries and theories often make the chemistry appear disjointed, haphazard and idiosyncratic.

One interesting aspect of this new volume is the use of a large number of high-quality line drawings and portraits which have been integrated into the text of the book. Hopefully this is a positive sign that the example set by the *Bulletin for the History of Chemistry* has made historians more sensitive to the use of such pictorial materials than has been the case previously, though perhaps we are immodestly taking more credit than we deserve. In any case, this is an excellent book which belongs on the shelves of all serious students of the history of alchemy, chemistry, and medicine. *William B. Jensen, University of Cincinnati, Cincinnati, OH 45221.*

Enlightenment Science in the Romantic Era: The Chemistry of Berzelius and Its Cultural Setting. Edited by Evan M. Melhado and Tore Frängsmyr, Cambridge University Press, Cambridge, 1992. xiv + 246 pp. Cloth (Typeset), $49.95.

As is all too frequent with academic books these days, and especially with those in the humanities, the true content of this volume is revealed by its subtitle rather than its title and consists of a series of essays, by a distinguished team of chemical historians, dealing with various aspects of the life and science of Jöns Jakob Berzelius (1779 -1848), who was, without doubt, one of most influential European chemists of the first half of the 19th century. In addition to a brief introduction by the editors, the volume contains nine essays: "Berzelius and His Time" by Sten Lindroth; "'Truth, the Angel of Light': Berzelius, Agardh, and Hwasser" by Sven-Eric Liedman; "Berzelius and the Atomic Theory: The Intellectual Background" by Gunnar Eriksson; "Berzelius, Dalton, and the Chemical Atom" by Anders Lundgren; "Berzelius's Animal Chemistry: From Physiology to Organic Chemistry (1805-1814)" by Alan Rocke; "Novelty and Tradition in the Chemistry of Berzelius (1803-1819)" by Evan Melhado; "Berzelius as Godfather of Isomorphism" by Hans-Werner Schütt; "Berzelius, the Dualistic Hypothesis, and the Rise of Organic Chemistry" by John Hedley Brooke; and "Berzelius as a European Traveler" by Carl Gustaf Bernhard.

In keeping with current trends in the history of science, most of the essays tend to stress the details of the social, cultural, and philosophical context of Berzelius's life rather than the experimental and conceptual details of his science. Also surprising, at first glance, is the absence of a separate essay dealing with his electrochemical theory, though aspects of it (particularly its taxonomic consequences) are touched on in several of the essays, most notably those by Melhado and Brooke. However, this omission becomes understandable when one realizes that this topic was covered in great detail in Evan Melhado's 1981 monograph, *Jacob Berzelius: The Emergence of his Chemical System*, and that it is the intent of the present volume to fill in the details of Berzelius's life and work and, in particular, to examine its larger cultural context, rather than to present a comprehensive overview.

Though all of the essays are well done and highly informative, especially for a reader already familiar with the basic outline of Berzelius's life, and the technical production of the book is excellent, it is nevertheless difficult for the English-speaking reader, in the absence of an English translation of H. G. Söderbaum's monumental three-volume biography of Berzelius, to accurately gauge the novelty of those essays which focus on the biographical details of his life. Unhappily, the translation of foreign monographs, however important, does not form a part of the Weltanschauung of the present generation of historians of science, so that it is highly probable and highly regrettable that historians and chemists who cannot read

Swedish will continue, for the foreseeable future, to be denied access to what is certainly the single most important source of information on Berzelius. In the meantime, this small volume will do much to fill the void for the English-speaking reader. *William B. Jensen, Department of Chemistry, University of Cincinnati, Cincinnati, OH 45221.*

Eilhard Mitscherlich: Baumeister am Fundament der Chemie. Hans-Werner Schütt, Deutsches Museum in Kommission bei Oldenbourg Verlag, Munich, 1992. 192 pp. Cloth (Typeset), NP.

Schütt has here provided us with one of the very few full modern biographies of a 19th-century German chemist. Although there is much on his subject's well-known "difficult" personality, Schütt maintains his principal focus on career matters - isomorphism remained Mitscherlich's greatest discovery, but numerous discoveries in organic, inorganic, geological, and biological chemistry flowed regularly out of his Berlin laboratory. As one of the most significant chemists of the century, Mitscherlich deserves such attention, and Schütt has spared no pains to give us a detailed and accurate vision of the man and his work. *Alan J. Rocke, Department of History, Case Western Reserve University, Cleveland OH 44106.*

Enjoying Organic Chemistry, 1927-1987, Egbert Havinga, American Chemical Society, Washington, DC, 1991. xvii + 122 pp. Cloth (Typeset), $24.95.

Sadly, Egbert Havinga's death in 1987 cut short a brilliant career and caused this book to be the first posthumous publication in this special series published by the American Chemical Society. Far more than simply a hard-working scientist, Havinga was widely admired for his humane and gentle nature, for his wide knowledge of arts and letters, for his nearly inexhaustible storehouse of chemical information, and for his deep humility that made him constantly praise the efforts of his many students while always down-playing his own achievements. The long exciting tradition of Dutch scholarship and intellectual curiosity was never better served than by Havinga.

As with so many individuals involved in this series, a very significant portion of Havinga's career dealt with stereochemical themes. In keeping with such a focus, Havinga's first staff position was in the Veterinary Faculty of the University of Utrecht, in precisely the same building where "van't Hoff had found his Pegasus," to paraphrase the now ironic sarcasm once leveled by Kolbe against van't Hoff. As Havinga's research program progressed, a style of work emerged that cleverly combined both physical studies and classical organic chemistry. Beginning with his own doctoral research that explored the stereochemical implications of chemistry in monolayers (still an intriguing and far from well-understood area with important biophysical implications) and followed by bold forays into the realm of spontaneous resolution of racemic mixtures, the maturing independent stereochemical work of Havinga followed a distinctly personal pathway. Long before it became fashionable, Havinga embarked on a research program in which each doctoral student not only had to prepare a series of target substrates exhibiting systematic variation in structure, but then had to subject this collection of compounds to rigorous scrutiny by the most sophisticated physico-chemical instrumentation currently available. The result was a treasure trove of data showing how properties such as density, dipole moment, infrared absorption, and electron diffraction patterns, were a function of a particular compound's three-dimensional structure.

Many aspects of alicycles that are now taken so completely for granted as worthy of mention only at the most elementary level in our standard undergraduate textbooks were first explored and established by the work of Havinga and his school. Given the somewhat reclusive character of Havinga's contemporary, the Norwegian chemist, O. Hassel, the mainstream popularity of Havinga's efforts helped secure a much more appreciative audience for alicyclic stereo-physical properties. In addition, such studies helped lay the foundations of conformational analysis as later developed by D.H.R. Barton. Havinga's systematic investigations of five-, six-, seven-, and eight-membered rings uncovered many surprising phenomena, such as the still intriguing "anomeric effect" that is of such importance in carbohydrate chemistry. While there was an initial desire to examine alicyclic compounds that were directly related to common natural product examples, the investigations gradually achieved their own momentum. Even today, force-field calculations and NMR studies of alicycles continue to excite the curiosity of investigators. Extremely weak intermolecular interactions, such as the "benzene effect" (p. 16), still defy complete understanding.

In following Havinga's discussion of how his research interests evolved, one cannot escape the sophisticated and fascinating marriage that he achieved between precise measurement of apparently obscure physical characteristics and phenomena, coupled with his being able to come up with valid and generally applicable rationalizations as to what was being observed. A common criticism of organic chemistry in the past was that the discipline resembled a colossal slag heap of unrelated facts. Individuals such as Havinga have helped enormously to make such notions less tenable and thereby have helped to transform organic chemistry into a vibrant, mature discipline with its own internal logic and excitement.

One of the greatest intellectual advances in chemistry, the conservation of orbital symmetry, ennunciated so powerfully by Woodward, Hoffmann, Fukui, and others, had a number of critical antecedents in the now classic studies of Havinga on Vitamin D. Havinga's series of superbly detailed experimental publications on the thermal and photochemical transformations of Vitamin D analogs provides an excellent complement to the work of Woodward and Eschenmoser on the synthesis of Vitamin B-12. Together, both projects served as a "prompt" to focus attention on electrocyclic reactions. A powerful lesson has been provided to the scientific community demonstrating how general interest in a particular compound (usually due to some valuable biological activity) can draw researchers into a very detailed examination of esoteric and unusual behavior. From such studies, there emerge deeper insights able to propel all of chemistry forward - in a sense, a kind of cosmic reward for a seemingly micro-reductionist focus.

At a time when photochemistry was still an emerging discipline, it must have taken real courage for Havinga to have made such a commitment to the Vitamin D problem. Nevertheless, once he began, Havinga prevailed. Observation followed observation until, with the able assistance of his collaborator, the brilliant theoretician Oosterhoff, in 1961 the importance of orbital symmetry gained recognition. The attention to detail that was so characteristic of Havinga is what really made the difference. If one wanted to press an analogy, Havinga's focus on product analysis of seemingly nearly identical materials and a desire to explain their rational formation reminds one of Pasteur's efforts to understand the nature of racemic tartaric acid. For this system, Pasteur was only able to make progress when microscopic examination of the crystalline racemic tartrate revealed the previously overlooked presence of a random jumble of enantiomeric crystals.

As is so common with many "giants" of organic chemistry, Havinga had a pronounced tendency to return again and again to the same problem - a kind of intellectual willingness to mine the "Mother Lode." Careful analysis of the Vitamin D by-products had revealed the presence of a large number of intriguing materials. Obviously tedious isolation of by-products present only in ultra-trace quantities presented a serious challenge even in regards to collection of sufficient material (i.e. a few milligrams) for spectroscopic characterization. This greatly complicated the difficulty in arriving at unambiguous structures for these materials. Why are the obscure by-products present? A lesser chemist might have ignored this loose end but Havinga's attention to detail encouraged his own group and others to press forward. Ultimately, knowledge of the structures of such Vitamin D "molecular mutants" as the toxisterols and the suprasterols has given chemists valuable mechanistic insights into what is actually a very complex photochemical system. Recognition of the inherent complexity of much chemical behavior may be a good sign that, after hundreds of years, chemistry may finally be reaching maturity and can indeed explain the "real world."

Coming into organic photochemistry at its infancy, Havinga's group made another major discovery by their serendipitous observation of nucleophilic aromatic photosubstitution. From their first observations in 1954 and throughout the late 1960s, these Dutch chemists carried out an extensive exploration of the scope and mechanism of this reaction class. The persistent attention to detail that Havinga had originally given to his Vitamin D work was profitably transferred to this classic investigation. Studies on aromatic photosubstitution allowed Havinga to probe fundamental aspects of photochemistry, such as the importance of triplet and singlet species and the ability to create reactive transient intermediates via high intensity nanosecond flashes. All of this was done within the context of reactions that were similar to the familiar ground state chemistry known to every organic chemist. As always, Havinga's photosubstitution work exhibits his own special style, an initial spartan simplicity that made possible seminal insights only to be followed by additional detailed studies that cleared up any remaining confusion. Always, his experiments were carefully crafted with great elegance and relevance.

Even in what appears to be a "minor" investigation - the study of nitroso dimerization - Havinga displays his characteristic ability of drawing the reader into a shared interest in substrate-dependent reactivity and mechanistic subtlety. His work always piques our curiosity. Forever present is an intriguing virtue, perhaps best described as the quality of being a "natural scientist," that is found only in a very small percentage of practicing academic and industrial scientists. These "naturals" are the men and women who have a remarkable knack for extracting something very interesting from even the most seemingly mundane scientific study. To reverse-paraphrase, "they look locally and perceive globally." Havinga serves as an archetypical example of just such an individual.

In his last major research effort, Havinga brought together his interest in all aspects of physical organic phenomena to probe the mechanistic features of the structurally well-characterized enzyme ribonuclease. As one of the first enzymes to have its structure elucidated, ribonuclease has long fascinated chemists. How can one make the leap from a hodge-podge of atoms somewhat resembling pizza dough onward to proposing the mechanism of action of a highly efficient catalyst? Without any convenient way to capture the enzyme-substrate activated complex, chemists have been forced to rely upon completely indirect evidence. The synthesis of numerous analogs and the systematic investigation of trends in their catalytic behavior was the key employed by Havinga as well as many other early participants in this field. As a mature artist and craftsman of science, it would have been out of character for Havinga to have taken any short-cuts. Instead, by adopting a courageously bold frontal assault, he prepared the requisite substrates and was indeed able to propose a credible mechanism. Much work has led to much understanding. The message: no pain, no gain.

Personal characteristics of Havinga that are showcased within this book include the humility, gentleness, humane sensitivity, and enormous decency that, from all indications, were essential features of this man's behavior. Even to the extent of almost always citing his graduate students' efforts in lieu of his own contributions, Havinga exhibited a rare degree of intellectual generosity. His discussions of the various cultural and non-scientific activities reveal a widely read, highly philosophical mindset. From his youth on into his mature years, this man maintained and cultivated an enormously wide circle of loyal friends who greatly appreciated his intellect and strength of character. These were friendships that persisted for decades. As might have been expected out of respect for such a noble individual, one of Havinga's colleagues, Harry Jacobs, in what was basically a labor of love, helped to guide the extant manuscript into an effective posthumous document. In a touching, but very characteristic fashion, Havinga pays tender tribute at the end of his book to his partner for life, his beloved wife, Louise D. Oversluys, by stating that he would follow exactly the same career path all over again but only if he could once more enjoy her companionship, moral support, and spirit of adventure. *John Belletire, Department of Chemistry, University of Cincinnati, Cincinnati, OH 45221.*

LETTERS

The Stereochemistry of Benzene

I should like to say how much I appreciated Dr. Paoloni's nonpolemical article on "Stereochemical Models of Benzene, 1869-1875" (*Bulletin*, **1992**, *12*, 10-24). I was pleased to see this area of research pursued since these questions were the ones that got me started in my research in the history of stereochemistry while an NSF Science Faculty Fellow at the University of Wisconsin working with Aaron Ihde in 1968-69. How chemists attempted to reconcile the planar structure of benzene with van't Hoff's tetrahedral carbon atom becomes even more interesting when you examine the numerous "space filling" models of benzene proposed in the latter part of the 19th and early 20th century. The problem is also entangled with the early development of conformational analysis.

I would also like to offer my congratulations on this excellent publication. I can remember the frustration many of us HIST members experienced in the 1980s as we struggled to find ways of raising the $10,000-20,000 required to start and publish a journal to replace *Chymia*. We never found the money. Desktop publishing, Bill Jensen, and a newly "professional" group of HIST members arrived to revitalize what had been a somewhat moribund activity of the American Chemical Society. *Bert Ramsay, Eastern Michigan University*

Chemical Slide Rules

I am sure William Williams' article on "Some Early Chemical Slide Rules" (*Bulletin*, **1992**, *12*, 24-29) will elicit many comments and contributions of additional "chemical" slide rules. An early 20th century German-made and designed slide rule "nach Dr. Tisza" distributed in the USA by the Scientific Materials Company of Pittsburgh, PA was introduced as part of a promotional brochure (for my "chemical" calculator) at the August 1993 meeting of the American Chemical Society. The slide rule in question contained a number of element symbols and chemical formulas to be used to calculate chemical "Equivalencies." The major limitation of the traditional "chemical" slide rule was that there simply was not enough space to place all of the formulas for which one might have wished to calculate a formula mass. This limitation, as well as a number of other shortcomings of slide rules in general, has been overcome with my patent (pending?) chemical calculator. The chemical formula, as well as chemical equations, can be easily "written" from the periodic table keypad which then carries out the required series of operations to calculate the formula mass. [Editor: Further information about Dr. Ramsay's calculator can be obtained by writing to him at his company: Chemical Concepts Corporation, 912 North Main Street, Ann Arbor, MI 48104] *Bert Ramsay, Eastern Michigan University*

* Since the publication of my article on "Some Early Chemical Slide Rules" (*Bulletin*, **1992**, *12*, 24-29) I have uncovered several additional references and have also received several letters from readers containing further information on the locations of existing examples, which I have summarized below:

A. John Johnston's *Manual of Chemistry* (Thomas Cowperthwait, Philadelphia, 1846, p. 133) mentions the Beck-Henry scale.

B. Professor B. P. Huddle, of Roanoke College, Salem, VA, sent photocopies of an "Ashley" rule in his possession. The photocopy of his rule shows what was unclear on the illustration used in the *Bulletin*; the manufacturer was Keuffel & Esser Company and it carried patent dates of 5 June 1900 and 22 December 1908. A good magnifying glass on the "Ashley" illustration in the 1914 E. H. Sargent catalog revealed that it was indeed made by K & E. Professor Huddle's rule presented formulas for "ACID, BASE, SALT," on one side, while the other side listed "OXIDE, ELEMENT."

C. David J. Bryden, of the Royal Museum of Scotland in Edinburgh, sent several pertinent items about different chemical slide rules:

i) In 1834, Carpenter's Chemical Warehouse, 301 Market Street, Philadelphia, published a "Catalogue of Chemical and Philosophical Apparatus, Utensils and Materials, manufactured by a distinguished artist of this city." (G. Carpenter, *Essays on some of the most important articles of the Materia Medica* ... , G. W. Carpenter Chemical Warehouse, Philadelphia, 1834, p. 285). Among the items in that catalog was a "Sliding Scales of Chemical Equivalents, in which oxygen is called eight, as taught in the schools of America."

ii) There is a chemical equivalents rule produced by Newman, the instrument maker at the Royal Institution, in the Whipple